

## PRELIMINARY RESEARCH PROPOSAL (COE) (FY05)

TITLE: Sampling PIT-tagged juvenile salmonids migrating in the Columbia River estuary

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PROJECT DURATION: Five years (2000-2005)

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### PROJECT SUMMARY

We believe that detecting passive integrated transponder (PIT) tagged juvenile salmon in the estuary will allow survival to be partitioned between river and ocean environments, and facilitate a more complete understanding of survival and timing differences between transported and inriver-migrant groups. These data may lead to management actions to increase survival by adjusting ocean entry timing or changing the proportion of fish transported or left to migrate

inriver. Sampling in the lower estuary through the summer and fall (target Snake River fall chinook salmon transportation study if conducted) would provide important information on life history strategies in the estuary by this little understood population.

In 2005, we propose to assess migration timing to the estuary for yearling chinook salmon and steelhead from tagging operations on the Snake and Columbia Rivers. For these studies, roughly 300,000 PIT-tagged yearling chinook salmon and 0 steelhead will be released into the Snake River below Lower Granite or Ice Harbor Dams plus another 26,000 from Lyons Ferry Hatchery (D. Marsh, NMFS, NWFSC, Seattle, WA, Pers. commun., July 2004). We will also evaluate migration timing and survival of PIT-tagged chinook salmon released from major hatcheries throughout the Snake River Basin (about 94,000 total) plus another 15,000 from Carson Hatchery in the lower Columbia River (L. Basham, Fish Passage Center, Pers. commun., July 2004). If sufficient numbers of PIT-tagged fish are released by the mid-Columbia Public Utility Districts, we will evaluate migration timing to the estuary and may estimate survival through the hydropower system for mid-Columbia River stocks (120,000 chinook from Priest Rapids Dam, Grant Co. PUD, R. Richmond, Biomark, Pers. commun., July 2004). About 480,000 steelhead will be tagged and released in the upper Columbia River with about 20,000 of those transported from McNary Dam (D. Marsh, NMFS, NWFSC, Seattle, WA, Pers. commun., July 2004).

Estuarine detections of PIT-tagged fish will provide an index of PIT-tagged salmonids known to be in the upper end of the estuary for use by researchers to assess how avian predators in the lower river select prey by comparing difference in prey selectivity by species, and rearing

or migration history. Further, if appropriate marked fish are available during the spring, we will compare migration timing of radio-, sonic-, and PIT-tagged fish to and through the estuary.

If sufficient numbers of summer migrating subyearling chinook salmon are PIT-tagged as in 2002, we propose to again extend sampling during July and August to provide estuarine behavior and timing information for this ocean-type life-history strategy. This appears feasible because a variety of marking programs are being considered for 2005 to evaluate fish transportation during summer, including perhaps 200,000 subyearling chinook salmon tagged at either Lyons Ferry Hatchery or Lower Granite Dam or both (D. Marsh, NMFS, NWFSC, Seattle, WA, Pers. commun., July 2004) and 300,000 at mid-Columbia Public Utility District projects (G. McMichael, Battelle PNNL, Pers. commun., July 2004).

We propose to again deploy a small-boat pair trawl with a salt-water-capable antenna in the lower estuary in areas currently inaccessible to the large pair trawl. The goal of this objective is to develop a small PIT-tag detector that can be used in the lower river to determine estuarine habitat utilization and preferences and possibly in other applications such as small rivers and high-volume bypass channels.

Previous research at Jones Beach revealed a substantial component of the migrant population in the estuary to be along the shoreline (Dawley et al. 1985; Dawley et al. 1986; Ledgerwood et al. 1990). We propose to continue a limited use of a trawl-like system anchored along the shoreline at Jones Beach to sample for PIT-tagged fish not accessible to the mid-channel trawl systems. Such a shoreline detection system was used at Jones Beach on 6 days in 2004 (21 hours of detector on-time and 0 detections of migrant fish). We did PIT-tag and released test fish into the net and viewed passing fish and observed net configurations with

cameras and divers. The system proved to have low impacts to fish and worked well electronically. Logistically we made several minor improvements to the shoreline system and gained useful incites regarding fish behavior near PIT-tag antennas and nets.

## BACKGROUND

Migration behavior and survival of juvenile salmonids passing through the lower Columbia River from Bonneville Dam to the mouth is poorly documented. Reasons include concern for impacts from physically handling large numbers of fish, inaccuracies in mark application and identification (brands and fin clips), and difficulty in sampling logistics which lead to inconsistent and biased sampling results. However, precise estimates of migrational timing differences among juvenile salmonid populations traveling through the estuary would help evaluate factors affecting survival and the contribution of various enhancement activities on adult returns. In particular, timing and post-release survival of fish released from transportation barges could be compared to those fish migrating inriver, and thus identify the potential effects of differential delayed mortality associated with transportation.

In 1966, National Marine Fisheries Service researchers began evaluating migrational characteristics and relative survival differences between marked groups of juvenile salmonids released throughout the Columbia River Basin. Sampling was conducted in the estuary and occasionally in the nearshore ocean (Miller et al. 1983; Dawley et al. 1986; Johnsen and Sims 1973; Ledgerwood et al. 1990; Ledgerwood et al. 1991; Ledgerwood et al. 1994; Miller 1992). Purse and beach seines were selected as the primary sampling gear because of greater catch efficiency and less injury to the intercepted salmonids. Coded-wire tags (CWT) proved a useful

marking technique for relative survival comparisons, compared to the uncertainty associated with poor mark application or retention using fin clip and cold brand methodologies. However, because of the large number of recoveries necessary to detect statistically significant differences among treatment groups using CWTs, it was necessary to sample as many as 367,000 fish. Concern over handling such large numbers of juvenile fish led us to seek alternative methodologies which greatly reduced impacts to fish when assessing migration behavior and survival as when detecting PIT-tagged juvenile salmonids. Detecting PIT-tagged fish in the estuary would also provide a means to evaluate juvenile salmon migrations independent of hydroelectric facilities.

Therefore, in 1995, we began testing a PIT-tag detection system for use in the freshwater portion of the estuary. Between 1995 and 1999, we detected over 17,000 juvenile salmonids tagged with 400 kHz PIT-tags at the entrance to the Columbia River estuary at Jones Beach (RKm 75). In 2000, our electronic equipment was adapted to interrogate the 134.2 kHz PIT-tag used in the Columbia River Basin, and through 2004 we have detected over 62,000 juvenile salmonids implanted with these tags.

In 2004, we continued evaluation of specialized pair-trawls containing PIT-tag detectors for estuarine interception of PIT-tagged juvenile salmonids. Target fish were PIT-tagged juvenile spring/summer chinook salmon (*Onchorynchus tshawytscha*) released from April through early July each year to compare smolt-to-adult return rates (SARs) between inriver migrating and barge-transported fish (Transportation Study). We compared migration behavior, timing, and relative survival of fish groups transported and released downstream from Bonneville Dam with groups that migrated inriver. We provided dates of estuarine passage that allow comparison of

SARs for groups with similar ocean-entry timing and made estimates of survival for inriver migrants to Bonneville Dam. We also provided observations of the diel behavior of juvenile salmonids in the estuary, differences in migration timing between radio- and PIT-tagged fish, and documented the presence of tagged smolts at the entrance to the estuary for use in assessing the relative vulnerability of juveniles to birds nesting in the middle and lower estuary.<sup>1</sup>

Our studies suggest the temporal distributions of transported PIT-tagged yearling fish at Jones Beach were similar between years with the possible exception of the extremely low flow year in 2001, where passage durations between transported and inriver migrants were significantly different for fish tagged at Lower Granite Dam on the same date. We detected transport fish from each release for only a few days, whereas inriver migrants from each release at Lower Granite Dam were available for 2 to 3 weeks. We concluded that the longer, more uniform period of availability for fish released at Lower Granite Dam (inriver migrants) accounted for the increased number of detections for these fish compared to transported fish. There were also differences in average daily travel speed to Jones Beach for fish released from transportation barges just downstream from Bonneville Dam as compared to inriver migrants detected in the bypass system at the dam. For example, in 1999, travel speed to Jones Beach for yearling chinook salmon released from barges averaged 60 km/day compared to 94 km/day for inriver migrants detected at the dam, whereas for steelhead (*O. mykiss*) the travels speeds were 81 and 98 km/day for barged and inriver migrants, respectively.

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<sup>1</sup> Large colonies of Caspian terns and double-crested cormorants nest on dredge disposal and other islands located just downstream from Jones Beach.

The pair-trawl PIT-tag detection system operates independently from hydroelectric facilities and provides a unique opportunity to compare migration times between fish detected and not detected at Bonneville Dam. For example, for fish released at The Dalles Dam in 1999 and 2000, the average travel time to Jones Beach for yearling chinook salmon detected at Bonneville Dam was 6 and 9 hours longer than for those not detected at the dam, respectively; for coho salmon (*O. kisutch*) the travel times were 4 and 5 hours longer for detected fish in 1999 and 2000, respectively.

Daily estuarine sampling was consistent and detections of PIT-tagged fish were sufficient during the spring to provide survival estimates for inriver migrating yearling chinook salmon to Bonneville Dam from 1999 to 2004 and steelhead from 1998 to 2004 using a modified single-release model (Williams et al. 2001; Steven G. Smith, NMFS, NWFSC, Seattle, WA, Pers. commun., July 2001). In 2004, we modified a trawl by extending the floor 9.2 m forward of the foot-rope rather than 4.5 m as in previous designs. The longer floor apparently was effective at decreasing the escape rate of yearling chinook salmon from the trawl and increased our detection rates from about 2% to about 3% of those fish previously detected at Bonneville Dam (n = 27,184 detections at Bonneville Dam).

We propose to continue development of a smaller PIT-tag trawl and detection system for use in restricted waters of the lower estuary where the large trawl can not be safely used. The small trawl antenna system and associated electronic components were proto-types designed to function in salt-water. We used this system in 2002 to develop sampling protocols and equipment required in the high current and constricted areas of the lower estuary and in 2004 applied these procedures to sample PIT-tagged fish near the rivers mouth (between RKm 10 and



RKm 39). While the number of detections were disappointing (about 1 fish per hour of detector on-time) we did detect nine individual fish at both upper and lower estuary sampling sites. The range in timing between Jones Beach and the rivers mouth was between 16 to 40 hours and the variation in travel time between individual fish appeared directly correlated with the number of flood times encountered by the migrants following detection at Jones Beach. We originally speculated that the small trawl used in 2002 was sampling at too shallow a depth to (2.5 m) and therefore modified the trawl design to sample to a depth of 4 m in 2004. We also increased the overall size of the trawl body (from 3.6 m square at the trawl body entrance in 2002 to 4.9 m square in 2004) with little result. In salt-water, 80% of the detected fish were steelhead compared to 16% in the upper estuary which suggests a depth bias with the smaller trawl. We used the same antenna in both years but had added a lead-shielding to the outside perimeter of the antenna to improve detection range in 2004 without increasing the fish passage opening (81 cm wide by 30 cm tall). We now believe in it is possible that fish are reluctant to pass out of the trawl body through the salt-water antenna and instead swim forward and escape around the floor (only 1.5 m forward of the foot-rope). It is also possible that the large-mesh extension wings are not effective at guiding fish to the trawl body. We plan on using a larger opening salt-water antenna now possible using 'super-tags' that have longer read-ranges<sup>2</sup>, extending the floor further forward, and perhaps adding small mesh to the wings of the small trawl.

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<sup>2</sup> A 0.6 m by 1.5 m fish passage opening for a salt-water tolerant antenna may now be feasible (Bruce Jonason, pers. commun., July 2004).



## OBJECTIVES

### **Objective 1– Estimate survival through the Columbia River hydropower system for PIT-tagged yearling salmonids during April-June by conducting pair-trawl sampling.**

We propose to repeat previous PIT-tag detection efforts using a pair-trawl to estimate survival of major inriver-migrating release groups to the tailrace of Bonneville Dam. Further, if a transportation study is conducted for fish PIT tagged on the Snake River, estuarine detection rates will be used to compare seasonal trends in relative survival of transported fish released just downstream from Bonneville Dam to those inriver migrants detected in the juvenile bypass system at Bonneville Dam. We will also collect specific migration timing information for many other PIT-tagged groups. These data will provide supplemental information on transport benefits by comparing ocean-entry timing for barged versus inriver groups, form a basis to evaluate relative effects of bird predation on PIT-tagged salmonids, enable completion of survival estimates through the entire hydropower system, and provide the first post-release detection data on transported fish. Our goal is to detect 2% of PIT-tagged fish previously detected at Bonneville Dam.

### **Objective 2–Extend sampling into July and August for subyearling salmonids.**

Transportation of PIT-tagged subyearling salmon is new and little information on behavior and timing of these fish following release is available. Sampling in mid-river at Jones Beach during late June and July in 2002 and 2004 indicated that detection rates of subyearling salmonids were adequate to determine timing and behavioral differences with a single sampling crew. We will also sample intermittently to estimate the proportion of subyearling migrants

traveling along the shoreline at Jones Beach. Our goal is to detect 0.75% of the fish previously detected at Bonneville Dam. Sampling with the small trawl in the lower estuary during summer and fall could provide new information regarding possible residency of Snake River fall chinook salmon.

**Objective 3—Continue sampling in the lower estuary using the smaller, mobile PIT-tag detection system.**

During the peak of spring (May) and summer (July-Aug) when numbers of PIT-tag fish passing through the estuary are high, a modified small-trawl system will be deployed the lower estuary (RKm 10 to 35) to evaluate timing and possible residence of juvenile salmonids in brackish water.

## **METHODS**

Sampling will be conducted in the estuary at Jones Beach from April through June (yearling migrants) and in July and August (subyearling migrants) using run-of-the-river fish. The duration of research will depend on the presence of PIT-tagged fish from the studies mentioned above and possibly other major release groups of PIT-tagged fish. We will continue to use underwater video and divers to evaluate fish and net interactions and observe the behavior of fish as they move through the net and PIT-tag detector tunnels. Bi-weekly reports of preliminary research results will be provided to interested parties, and raw detection data will be available through the Columbia Basin PIT-tag Information System (PTAGIS) database (recovery site code is TWX--towed array experimental, large trawl; and ESX--estuary salt experimental, small trawl).

## **Trawl Designs**

### **Large Pair trawl**

We will utilize a surface pair-trawl similar to those used in previous years (Ledgerwood et al. 2004; Ledgerwood et al. 2003; Ledgerwood et al. 1997). The operational procedures include towing the pair-trawl upstream with the wings open while juvenile salmonids pass downstream into the trawl and exit through the detector tunnels. PIT-tag decoding is accomplished electronically and requires no handling or removal of juvenile salmon from the net.

The pair-trawl consists of a 91.5-m wing attached to each side of the 15.5-m body of the trawl containing the PIT-tag detector located where the cod-end is normally positioned. Two vessels are used for towing, thus the name pair-trawl.

### **Small Pair trawl**

In 2004, this trawl had a 4.9-m square opening to a 12.8-m long trawl body and 4-m-long floor of small mesh web (1.8-cm). Wings consisted of a 6.1-m-long small mesh section preceded by another 30-m-long section of large mesh (33-cm) webbing. Sample in the lower estuary was from near Buoy 10 (Rkm 10) to the Astoria Bridge (Rkm 35). Modifications of trawl design (eliminate large-mesh in the wings and a longer floor) and antenna (increase size of fish passage opening) are being considered as mechanisms to increase PIT-tag detection efficiency. We will continue nearly continuous monitoring of salinity, temperature and depth of the net while under tow and GPS positions are recorded for each fish detection and every 15 minutes.

### **Shoreline sampler**

In 2004, we modified a PIT-tag detection system originally used in 2003 in the Snake River (Regan McNatt, project leader). Our modified system consisted of a wing leading from one side of a small trawl body to shore (tapered in depth from 2.4 to 1.2 m). A second 2.4-m-deep by 15-m-long wing was attached to a 2.4-m-long pipe to keep the wing fully extended vertically in the water column. The pipe was floated by a buoy similar to our other trawls and a bridle-line from the pipe was attached via a 15-m-long line to another buoy from a permanent anchor system. The anchor was positioned such that when in sampling position the antenna was floated in about 3-m of water. The 0.9-m-diameter PVC antenna was supported on a buoy similar to that of our other trawls. Generally, we deployed the device near high tide and sampled the ebb current. Current velocities varied from 0 to 0.5 m/second. A video camera was mounted within the antenna and used to monitor fish passage real-time. Detection electronics and video cables lead to a small barge. Using a line to shore from the tip of the wing, we developed a method to “flush” the net for cleaning and to encourage fish to exit downstream through the antenna—again similar to our trawling procedure.

Beach seine sampling was conducted at Jones Beach on 26 May and 22 June and a total of 2,372 juvenile salmonids were processed—none were PIT-tagged (Curtis Roegner, project leader, pers. commun.). On 22 June we also had our shoreline sampler deployed adjacent to the beach seine site and we PIT-tagged 55 of the subyearling chinook salmon captured. These fish along with untagged fish captured in the seine were then released them into the shoreline sampler (4 batches of up to 15 PIT-tagged fish). We detected 45% of those released and detections came almost immediately (within 5 minutes) of release. Video observations revealed that many fish

continued to swim easily against a strong current (over 2 knots) directly in front of the camera for over 30 minutes. It is possible that the flushing action of the net caused them swim forward and escape rather than downstream through the antenna. We detected no natural migrant PIT-tagged fish and few were observed entering the trawl on camera. All electronics systems performed satisfactorily. By using wireless video one could use a much smaller platform for electronics components. In 2005, we will increase the antenna diameter (utilize the 0.6 tall by 1.8-m long antennas used in the Snake River, or larger).

### **Detector Design and Efficiency**

We continued using the two-coil antenna in 2002, and devised a test procedure to verify detector performance by positioning a 2.5-cm PVC pipe through the exact center of the antenna and passing a series of PIT-tags attached to a vinyl tape measure through the pipe. On each end of the PVC pipe we used a plastic funnel to guide the tags smoothly into pipe, i.e. "funnel tests." There were 50 PIT-tags positioned along the test tape at various densities (lengths) and orientations (in-line with the coils or at 45 degree angles). The tape was designed such that not all tags could be read. Generally, high density (0.3 m spacing) and poorly oriented tags (45 degrees to the coils) would disappear from the data records when the electronic systems were not working properly. We tested each antenna about once a week by passing the tape through the antenna 6 times (300 tags). The large 2-coil antenna read about 70% of the test tags and the small trawl antenna read about 90% of the test tags. The difference between the two antennas was related to the size of the electronic field -- the smaller opening of the salt-water antenna improved its performance. Since the funnel-pipe was positioned in the center of the antennas,

the procedure was conservative in that most fish pass closer to the antenna walls where read rates are higher. We expect t Funnel test results in 2004 using 'Super' PIT-tags confirmed superior performance of those tags within our antennas over the traditional 132.4 KHz tags; 92% and 100% through the center in the large- and small-trawl antennas respectively. We believe that *in situ*, about 95% of all PIT-tagged fish passing through the antenna systems were detected. In 2005, we propose to continue "funnel tests" on a weekly basis or more frequently if needed to verify electronic system and detector performance. Potentially we could construct a larger-diameter antenna for 2005 but may prefer to wait one additional year to evaluate performance of 'super-duper' PIT-tags to be introduced this coming year. We have few problems with fish-passage with the existing and reliable antenna used since 2001.

### Detection Rates

In 1996, a relatively high flow year (flood conditions at Jones Beach), detection rates for PIT-tagged fish (400 kHz) using the detector/trawl were 0.64% for inriver migrants previously detected at Bonneville Dam. This detection efficiency was similar to that attained at Jones Beach using a purse seine (Ledgerwood et al. 1994). In 1998, 1999 (400 kHz), 2000-2003 (134 kHz) we improved our detection efficiency of PIT-tags by sampling 7 days per week instead of 5 and extending our sampling effort using two daily sampling crews during the peak of the migration season. During the extended sampling periods, we detected over 2% of the inriver migrant salmonids previously detected at Bonneville Dam. During 2004, we increase the detection rate of yearling chinook salmon by about 30% by using a trawl where the floor of the trawl extended forward from the foot-rope about 9.2 m. We expect to again sample about 2 to 3% of the

available PIT-tagged fish during the peak of the yearling chinook salmon migration (April-June). During the subyearling chinook salmon migration period, using a single crew 5-days per week (but lower river flows), we expect to detect about 0.75% of the available PIT-tagged fish. Net cleaning and maintenance, river conditions, personnel and vessel considerations, and PIT-tag detector operation should be the only impediments to continuous operation of the PIT-tag detector equipped pair-trawl. Efforts to refine the net configuration and operational procedures to increase detection percentages and stimulate rapid passage through the net and detector systems will continue.

### **Physical Impacts to Intercepted Fish**

Passage of intercepted fish through the net and detector tunnel will be visually assessed using video cameras, and we will periodically use divers to assess net configuration and impacts to fish in areas not readily monitored by cameras. In addition, we will occasionally inspect areas of the net using a video camera mounted on a pole and adjust operations as needed. For example, when debris accumulations or other problems are observed, we reduce tow speed and pull the detection antenna to the surface to access the cod end of the net. When necessary, we disconnect the electronics and invert the entire net to clear debris.

### **SCHEDULE**

In 2005, we will sample for PIT-tagged juvenile salmon from April to early August. At the beginning and end of the yearling chinook salmon migration and throughout the subyearling chinook migration, a single crew will sample 5 or 6 days/week. During the peak of the yearling



migration season when both transport and inriver groups are passing, two crews will sample daily 7 days/week. Also, we propose to sample intermittently for about a week, with a shoreline sampler during this period with additional shoreline effort during the July-August time period. Beginning in 2003, we emphasized sampling at dawn and dusk (typical periods of increased detection rates) by running our evening shift through the night until relieved by a morning shift. The period of decreased sampling was from about 1400 to 1700 hours--a period characterized by high winds and difficult sampling conditions. We propose to repeat this strategy, conditions permitting, in 2005.

## **FACILITIES AND EQUIPMENT**

Facilities are located at the NMFS Point Adams Field Station (Hammond, OR) and at Jones Beach, OR. Vessels are moored at Kerry West Marina near Westport, Oregon. We may elect to change the large trawl electronics from the original Whit Patten transceivers to Destron-Fearing transceivers now standard at most hydroelectric facilities. We will test the performance of the large-trawl antenna system using an AC-powered Destron-Fearing transceiver and a "multiplex unit" (if available) making it possible to operate two detection coils using a single transceiver. If performance is satisfactory based on funnel testing, we will purchase Destron-Fearing equipment for the large trawl system in 2005. The transceiver change would allow the Whit Patten transceivers (no longer being manufactured) to be used by NMFS to recover PIT tags from bird colonies in the Columbia River Basin. We had two DC-powered Destron-Fearing transceivers (one was a backup) for the single-coil small-trawl system. One unit was lost when the trawl

wrapped Buoy 20 and the pontoon-raft flipped over. We will replace that unit and use the backup transceiver with the shoreline sampler when available.

We constructed a new large trawl in 2003 and rebuilt both the 1995 and 1999 nets after the 2003 season. All three trawls remain serviceable. We also constructed and used a larger 4.9-m square trawl in 2004 and have the original 3.7-m square trawl (backup). We may modify the 4-9-m trawl for use in the lower estuary in 2005. A 2.4-m square shoreline sampler and associated equipment is available from 2004. As in previous years, NMFS will provide towing and support vessels for testing the large trawl. For the small trawl, we will charter a 10-m stern reeling gill-net vessel and use two NMFS support vessels (an 8-m tow vessel and a 4-m inflatable), similar to 2004. NMFS will provide shoreline support and a skiff for use when sampling along the shoreline.

## DATA ANALYSIS AND STATISTICS

In 2005, PIT-tag interrogations of juvenile spring/summer chinook salmon from the transport and extra mortality studies at Lower Granite or McNary Dams, the comparative survival study, and possibly mid-Columbia River survival studies will constitute the primary sources of PIT-tagged fish. Secondary sources will include PIT-tagged fish previously detected at Bonneville Dam. Also, we will compare the detection patterns of PIT- and radio-tagged fish released from transportation barges with those from run-of-the-river and radio-tagged fish released at Bonneville Dam. If sufficient numbers of inriver migrating fish are detected, we will also evaluate detection rates associated with passage through multiple bypass systems.

Diel-catch patterns (number of fish detected per hour during daylight compared to dark hours) of yearling chinook salmon and steelhead are evaluated using one-way ANOVA (Zar 1999). The number of detections and the minutes within each hour that the detector was energized each day are separated into daylight- and darkness-hour categories, and mean hourly detection rates are pooled for wild and hatchery rearing types of each species for each sampling period. These mean hourly detections rates will be used as the source for the ANOVA. Diel detection curves are generally prepared for yearling chinook salmon and steelhead based on the average number of fish detected each hour weighted by the minutes within each hour that the detectors were energized. For the other species detected, there are generally too few detections for meaningful analyses.

Travel-time distributions for release groups of interest (e.g., among yearling chinook salmon and steelhead released from transportation barges, or between inriver migrants detected at Bonneville Dam and those released from transportation barges) will be compared using the 10th through 90th percentiles and the middle 80th percentile range. These two sets of statistics characterize the location, width, and shape of the distributions. Standard errors are estimated using bootstrap re-sampling techniques (Efron and Tibshirani 1993). Calculations of the 10th to 90th percentiles (by 10s) and the middle 80 percent are applied to each bootstrap sample for the group being compared, resulting in sets of 1,000 bootstrapped travel time difference estimates for each of the statistics, similar to the analysis presented for 1999 (Ledgerwood et al. 2003). We chose 1,000 samples to obtain reasonable variance estimates (Efron and Tibshirani 1993). The 95% confidence interval estimates were calculated as the 25<sup>th</sup> and 975<sup>th</sup> values of the ordered bootstrap estimates. Percentile or range difference estimates are considered significant at the

$\alpha = 0.05$  level if the value "0" is not contained in the intervals.

Multiple linear regression will be used to evaluate differences in travel speed to Jones Beach between inriver migrants and transported fish. Factors used in the regression models of travel speed included Julian date, flow, "treatment" (inriver migrant vs. transported), and two-way interaction terms for the three main effects. Flow data will be daily average discharge rates at Bonneville Dam ( $\text{ft}^3 \text{ sec}^{-1}$ ).

Binary logistical regression analyses will be used to compare daily detection rates among inriver migrants previously detected at Bonneville Dam to those released from transportation barges on the same dates as detection at Bonneville Dam. The daily groupings are treated as "cohorts" in the analysis (Hosmer and Lemeshow 2001). The daily inriver groups will be paired to barged-released fish on date of barge-release and selected to include only those PIT-tagged fish released at sites from McNary Dam upstream. Components of the logistic regression model are treatment as a factor and date as a covariate. The model estimates the log odds of the detection rate of the daily cohorts (i.e.,  $\ln[p/(1-p)]$ ) as a linear function of the components, assuming a binomial distribution for the errors.

Detection data from the estuary are essential to estimate survival of juvenile salmonids to Bonneville Dam, the last dam encountered by seaward migrants (Muir et al. 2001; Williams et al. 2001; Zabel et al. 2001). The probability of survival through an individual reach of river is estimated from PIT-tag detection data using a multiple-recapture model for single release groups (Cormack 1964; Seber 1965; Skalski et al. 1998). Seasonal average survival probabilities are estimated for yearling chinook salmon and steelhead migrating inriver from the Snake and mid-Columbia Rivers (dependant on release numbers). Estimates are obtained using component

reach survival probabilities for migration from Lower Granite Reservoir to McNary Dam and from McNary Dam to Bonneville Dam (Iwamoto et al. 1994, Williams et al. 2001). PIT-tag detection data from the estuary provided a minor contribution to estimates of survival probability from Lower Granite Dam to McNary Dam. However, they were essential to estimates of survival to Bonneville Dam from any upstream release site.

### EXPECTED RESULTS AND APPLICABILITY

It is important to assess fish migrational behavior and reach survival using the PIT-tag detector/trawl using a multi-year research approach to incorporate flow and the environmental variability into the analyses. The need for a multi-year repetition was demonstrated in 2001 when, based upon preliminary analyses, low-flow conditions appeared to dramatically change migrational timing for inriver and transport groups. Application of this technology using 132.4 kHz PIT-tag equipment improved reliability with a reduction in impacts on fish. Migration timing data from PIT- and radio-tagged fish will also allow these methodologies to be compared. Information gained on timing of PIT-tagged fish from various locations within the watershed to the estuary and the variability in timing between different groups, will help managers define future release strategies. These analyses now include data on transported fish, an addition that is essential to assess recovery efforts for depressed salmonid stocks in the Columbia River Basin.

Little is understood regarding the behavior, utilization, and distribution of Snake River fall chinook salmon. These are ESA listed fish generally presumed to migrate to sea during the summer. Recent evidence suggests that a large portion of the adults returning to Lower Granite

Dam migrated to sea as yearlings. Currently hydropower operations use transportation without spill to maximize smolt to adult return ratios. An evaluation comparing transport to bypass and spill options is being considered. It is possible that a portion of these subyearling migrants overwinter downstream of Bonneville Dam, perhaps in the upper or lower estuary. Detections of PIT-tagged fish with the small trawl in the lower estuary during the summer and perhaps into the fall months would help define their life history strategies.

### **COLLABORATIVE ARRANGEMENTS**

Collaboration with Oregon State University, U.S. Fish and Wildlife Service, and other researchers involved with the radio- and acoustic-tracking studies in the Columbia River will continue. PIT-tag interrogation data from the Jones Beach sampling efforts (site code TWX) will be uploaded in batches to the PTAGIS database thus providing regional access to estuarine passage of PIT-tagged fish. PIT-tag detector/trawl interrogation data will be used by NMFS and other researchers to assess differential predation on juvenile salmonids by Caspian terns and double crested cormorants. When practical we would again attempt to collaborate with NMFS researchers and use beach seine captured fish at Jones Beach to evaluate the efficiency and impacts of the shoreline sampler.

### **KEY PERSONNEL**

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